HYDROLOGICAL EFFECTS OF THE SEDIMENTS DEPOSITED OFF A HILLSLOPE AFFECTED BY RILL EROSION: PROJECT OUTLINES AND PRELIMINARY RESULTS

Giménez, R.*, Casalí, J., Campo, M.A.

Department of Projects and Rural Engineering, Public University of Navarre, Campus Arrosadia, 31006. Pamplona, Spain.
*rafael.gimenez@unavarra.es

1. Introduction

Soil erosion by concentrated flow generates rill networks on hillslope areas which are equivalent to river streamline networks reduced to a field scale. This is a common phenomenon observed and documented in agricultural lands (e.g., Evans, 1995) and mainly studied under laboratory conditions (e.g., Bryan and Poesen, 1989; Favis-Mortolock, et al, 2000). Nevertheless, the way these networks emerged and developed is hitherto not fully understood.

Erosion models normally envisaged rills as planar channels with enough flow energy to transport much of the sediment off the hillslope, where rills are developed, towards sedimentation areas. Recent findings (Giménez et al., 2004), however, show that eroding rill has topographical and hydraulic characteristics different from those present in a flat channel. Rill topography is characterised by an alternation of planar reaches (*steps*) and relative large depressions (*pools*). Over *steps*, flow is shallow, unidirectional and rapidly accelerating. In the *pool*, instead, the flow is deep, multidirectional and complex. In addition, a strong interrelation between rill flow and bed topography has been observed (Giménez et al., 2004). This feedback is, for example, the responsible of the slope independence of flow velocity in eroding rills (Govers, 1992; Giménez and Govers, 2001). This complexity is not observed in a channel with a flat surface. Yet, most of the present rill erosion models are based on hydraulic formulae borrowed from flat channels.

During rill formation, rill flow competence is indeed large enough to detach and transport even relatively coarse sediments, such as soil aggregates, off the hillslope. After formation, a rill may remain in the field for weeks or months. During this time, the rill is still a preferential pathway for water and sediment, often at lower flow rates than the rill's formative discharge. Assuming that a less intense flow will not be able to erode the preformed rill, rill topography can remain invariant in the meantime unless sedimentation becomes important. Giménez et al. (2007) show that at lower discharges, rill macro-roughness dramatically reduces the flow's competence to transport coarse sediments. Differences of one order of magnitude in transport between a rill and a flat channel of the same micro-roughness were observed under the same slope and discharge (Giménez et al., 2007). Therefore, we hypothesise that within the sedimentation area of a hillslope, rill erosion is able to generate a layer of sediment whose granulometric characteristics should be different from that of the sediment produced by interill erosion (i.e., by overland flow). Now, to what extent these granulometric differences lead to local disparities in the hydrological behaviour of soil profile (e.g., infiltration rate), is much uncertain.

The main objectives of this project are then (i) to evaluate the sedimentation rate generated by rill erosion in a hillslope and the granulometric characteristics of the sediment deposited off this hillslope, and (ii) to determine the incidence of this sediment on the hydrological properties of the sedimentation area. In addition, an extra aim is to gain insight into the spatial and temporal evolution of a rill network under field condition.

2. Materials and methods

2.1. Selection of the experimental site

An essential part of the present work is to find a proper field place to run the experiments. We need a piece of land with at least the following characteristics [the below terminology follows the USDA's (1993) Soil Survey Manual]:

(i) Normal to excessive relief (i.e., a sloping upland with a medium to rapid runoff) with (ii) a nearly uniform soil surface, and a (iii) simple or somewhat convex slope (rilling is more likely in a convex slope). (iv) A clear sedimentation area which normally occurs when there is a sudden break in the slope towards a nearly flat relief, lowland. (v) An homogenous and deep topsoil in order that rills develop entirely within a single type of material. (vi) A well defined contributing area which is directly related to runoff discharge over this plot. (vii) Finally, a clear rill network must be, under natural conditions, easily developed, and the whole rill network must occupy a rather small area (around 100 – 200 m^2) in order to facilitate its monitoring. We found a plot with the aforementioned characteristics within the region of Pitillas (Navarre, Spain). This is 18 m long, 8 m wide and 12% steep (Fig.1).

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whole soil profile will be carried out using a conventional double-ring infiltrometer.

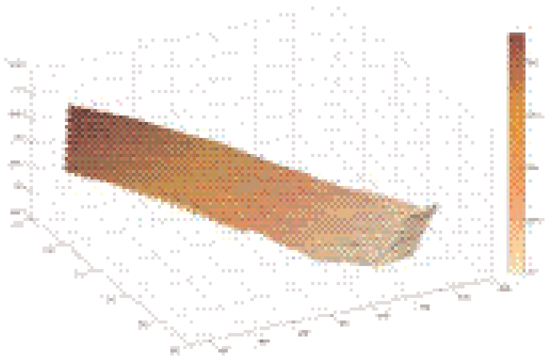

Fig. 1. Digital Elevation Model of the experimental plot.

2.2. Experimental protocol

Before starting the experiments, the whole plot was gently tilled with a disc plough in order to obliterate the pre-existing eroded rills. Then, it was surrounded by a wire fence to avoid soil disturbance by animal tramping.

Rainfall events are being measured every 10 min time by using an automatic pluviograph installed closed to the experimental plot. To measure soil moisture content, TDR probes were placed at the top, middle and bottom of the plot, at two different depths, i.e. 10 and 30 cm. Then, soil moisture content is being periodically measured using a portable TDR gauge that is connected in turn to each probe. In addition, continuous soil moisture content is being continuously registered by a soil water gauge connected to a datalogger. This last device is located at the middle of the plot and near to its lateral border, and at a depth of 25 cm

After any (important) rainfall event, the plot surface is being topographically surveyed by using a total station without using a prism located at around 8 m far from the low border of the plot (i.e., trampling over the plot is hence avoided). Rills (if any) are especially surveyed as in detail as possible. Besides, after a rainfall occurs, topsoil samples will be taken both in the rill and interrill sedimentation areas, and granulometric analysis of them will be carried out. In addition, in situ infiltration measurements will be made in both sedimentation areas by using a disk or tension infiltrometer. This allows to determined the infiltration rate (and characterize soil porosity) of few millimetres thin, sediment or soil layers by introducing water at subatmospheric pressure during just few minutes. Moreover, and again in both sedimentation areas, infiltration measurement of the whole soil profile will be carried out using a conventional double-ring infiltrometer.

3. Preliminary results

As preliminary results, Fig. 2 shows a plan view of the experimental plot with some incipient rills over it.

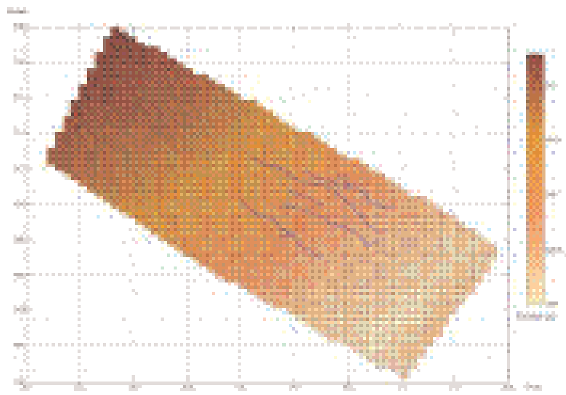

Fig. 2: Incipient rills observed in a plan view of the experimental plot.

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